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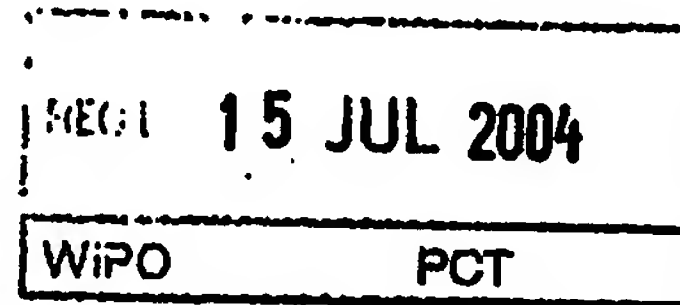
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Certificate

REPUBLIC OF SOUTH AFRICA

PATENT OFFICE
DEPARTMENT OF TRADE AND
INDUSTRY

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This is to certify that



the documents annexed hereto are true copies of:

Application forms P.1 and P.3, provisional specification and drawings of
South African Patent Application No. 2003/5452 as originally filed in the
Republic of South Africa on 15 July 2003 in the name of SASOL
TECHNOLOGY (PROPRIETARY) LIMITED for an invention entitled:
"PROCESS FOR PRODUCING LIQUID AND, OPTIONALLY, GASEOUS
PRODUCTS FROM GASEOUS REACTANTS".

PRIORITY DOCUMENT

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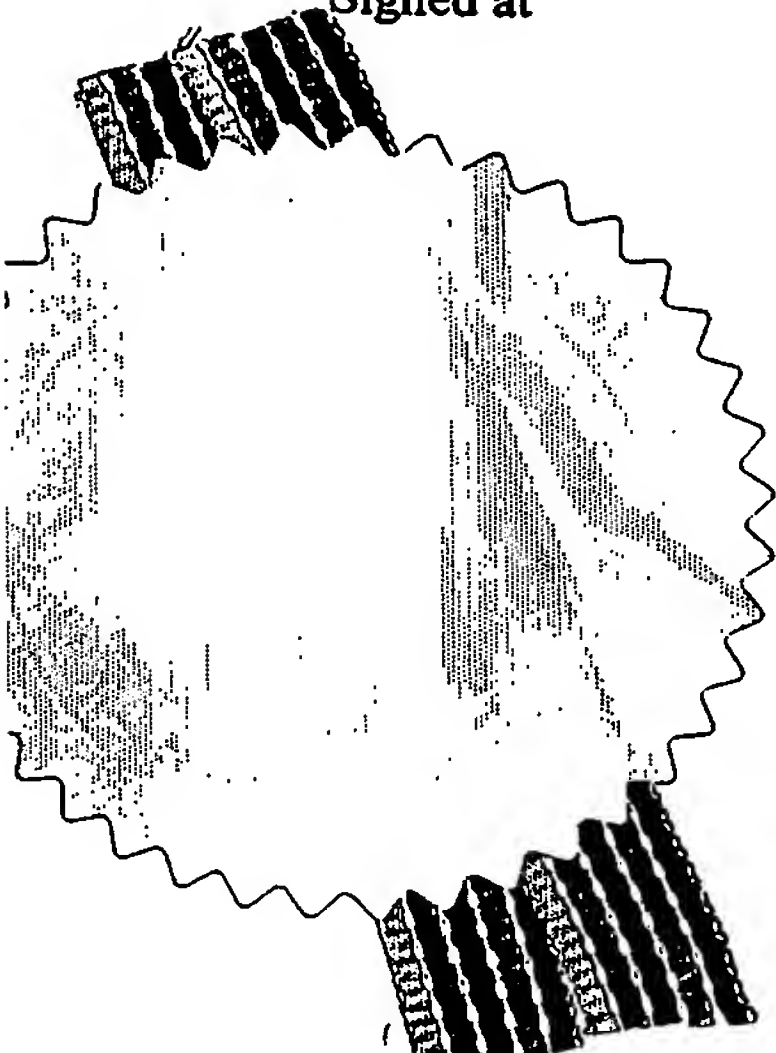
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24th dag van
day of
June 2004

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REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978
APPLICATION FOR A PATENT AND
ACKNOWLEDGEMENT OF RECEIPT
(Section 30(1) Regulation 22)

REPUBLIC OF SOUTH AFRICA
FORM P.1 REVENUE
(to be lodged in duplicate)

15.07.03

R 060.00

THE GRANT OF A PATENT IS HEREBY REQUESTED BY THE UNDERMENTIONED APPLICANT
ON THE BASIS OF THE PRESENT APPLICATION FILED IN DUPLICATE

21 01 PATENT APPLICATION NO. 2003/5452

INCOME TAX
A&A REF: V158215 GSKA/15/03

71 FULL NAME(S) OF APPLICANT(S)

SASOL TECHNOLOGY (PROPRIETARY) LIMITED

ADDRESS(ES) OF APPLICANT(S)

1 Sturdee Avenue, Rosebank, Johannesburg, Republic of South Africa

54 TITLE OF INVENTION

"PROCESS FOR PRODUCING LIQUID AND, OPTIONALLY, GASEOUS PRODUCTS FROM GASEOUS
REACTANTS"

Only the items marked with an "X" in the blocks below are applicable.

☐ THE APPLICANT CLAIMS PRIORITY AS SET OUT ON THE ACCOMPANYING FORM P.2. The earliest priority claimed is

Country:

No:

Date:

☐ THE APPLICATION IS FOR A PATENT OF ADDITION TO PATENT APPLICATION NO

21 01

☐ THIS APPLICATION IS A FRESH APPLICATION IN TERMS OF SECTION 37 AND BASED ON
APPLICATION NO

21 01

THIS APPLICATION IS ACCOMPANIED BY:

- ☒ A single copy of a provisional specification of 19 pages
- ☒ Drawings of 2 sheets
- ☐ Publication particulars and abstract (Form P.8 in duplicate) (for complete only)
- ☐ A copy of Figure of the drawings (if any) for the abstract (for complete only)
- ☐ An assignment of invention
- ☐ Certified priority document(s). (State quantity)
- ☐ Translation of the priority document(s)
- ☐ An assignment of priority rights
- ☐ A copy of Form P.2 and the specification of RSA Patent Application No
- ☒ Form P.2 in duplicate
- ☐ A declaration and power of attorney on Form P.3
- ☐ Request for ante-dating on Form P.4
- ☐ Request for classification on Form P.9
- ☐ Request for delay of acceptance on Form P.4
- ☐ Extra copy of informal drawings (for complete only)

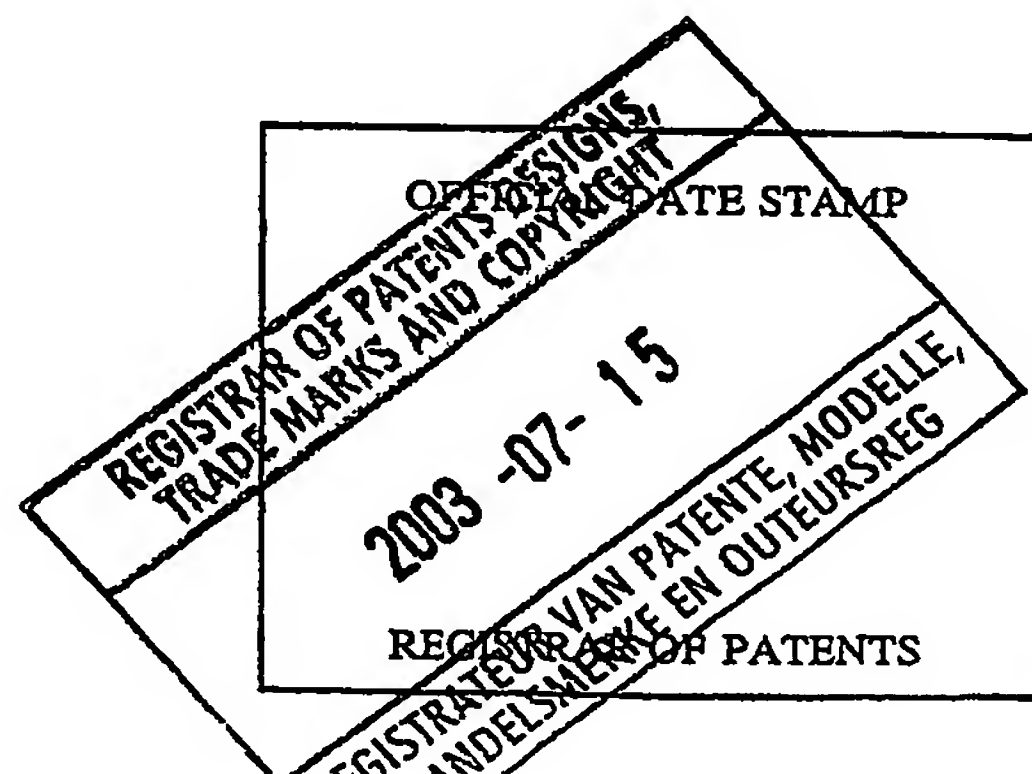
21 01

74 ADDRESS FOR SERVICE: Adams & Adams, Pretoria

Dated this 15 day of July 2003

ADAMS & ADAMS
APPLICANTS PATENT ATTORNEYS

The duplicate will be returned to the applicant's address for service as
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REPUBLIC OF SOUTH AFRICA
PATENTS ACT, 1978
DECLARATION AND POWER OF ATTORNEY
(Section 30 - Regulation 8, 22(l)(c) and 33)

PATENT APPLICATION NO		
21	01	2003/5452

A&A Ref: V15821 GSK

LODGING DATE	
22	15 JULY 2003

FULL NAME(S) OF APPLICANT(S)	
71	SASOL TECHNOLOGY (PROPRIETARY) LIMITED

FULL NAME(S) OF INVENTOR(S)	
72	VOGEL, ALEX PHILIP

EARLIEST PRIORITY CLAIMED	COUNTRY	NUMBER	DATE			
	33	---	31	---	32	---

NOTE: The country must be indicated by its International Abbreviation - see schedule 4 of the Regulations

TITLE OF INVENTION	
54	"PROCESS FOR PRODUCING LIQUID AND, OPTIONALLY, GASEOUS PRODUCTS FROM GASEOUS REACTANTS"

* I/we *Kuis Dancourt*

hereby declare that :-

1. I/we am/are the applicant(s) mentioned above;
- ** 2. I/we have been authorized by the applicant(s) to make this declaration and have knowledge of the facts herein stated in the capacity of *Authorized Signatory* of the applicant(s);
- *** 3. the inventor(s) of the abovementioned invention is/are the person(s) named above and the applicant(s) has/have acquired the right to apply by virtue of an assignment from the inventor(s);
4. to the best of my/our knowledge and belief, if a patent is granted on the application, there will be no lawful ground for the revocation of the patent;
- **** 5. this is a convention application and the earliest application from which priority is claimed as set out above is the first application in a convention country in respect of the invention claimed in any of the claims; and
6. the partners and qualified staff of the firm of ADAMS & ADAMS, patent attorneys, are authorised, jointly and severally, with powers of substitution and revocation, to represent the applicant(s) in this application and to be the address for service of the applicant(s) while the application is pending and after a patent has been granted on the application.

SIGNED THIS *4* DAY OF *September* 20 *03*

Company Name: *SASOL TECHNOLOGY (PROPRIETARY) LIMITED*
Full Names: *Kuis Dancourt*
Capacity: *Authorized Signatory*

* (no legalization necessary)
In the case of application in the name of a company, partnership or firm, give full names of signatory/signatories, delete paragraph 1, and enter capacity of each signatory in paragraph 2.
** If the applicant is a natural person, delete paragraph 2.
*** If the right to apply is not by virtue of an assignment from the inventor(s), delete "an assignment from the inventor(s)" and give details of acquisition of right.
**** For non-convention applications, delete paragraph 5.

A & A Ref No: V15821 GSK

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PRETORIA

FORM P6

REPUBLIC OF SOUTH AFRICA
Patents Act, 1978

PROVISIONAL SPECIFICATION
(Section 30 (1) - Regulation 27)

21	01	OFFICIAL APPLICATION NO
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2003/5452

22	LODGING DATE
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15 July 2003

71	FULL NAME(S) OF APPLICANT(S)
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SASOL TECHNOLOGY (PROPRIETARY) LIMITED

72	FULL NAME(S) OF INVENTOR(S)
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VOGEL, ALEX PHILIP

54	TITLE OF INVENTION
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"PROCESS FOR PRODUCING LIQUID AND, OPTIONALLY, GASEOUS PRODUCTS FROM GASEOUS REACTANTS"

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THIS INVENTION relates to a process for producing liquid and, optionally, gaseous products from gaseous reactants.

10

According to the invention, there is provided a process for producing liquid and, optionally, gaseous products from gaseous reactants, which process includes

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feeding, at a low level, gaseous reactants into a slurry bed of solid catalyst particles suspended in a suspension liquid;

20

allowing the gaseous reactants to react as they pass upwardly through the slurry bed, thereby to form liquid and, optionally, gaseous products, with the reaction being catalyzed by the catalyst particles and with a product mixture comprising liquid product and catalyst particles having a range of sizes, being formed;

25

subjecting, in a primary filtration stage, the product mixture to primary filtration by passing the liquid product through a filtering medium having a plurality of filtering openings through which the liquid product passes, with the liquid product passing through the filtering openings in a first direction and with the filtering openings having a controlling dimension of x microns, so that large catalyst particles having a particle size greater than x microns are separated from the liquid product, thereby to obtain a primary filtrate comprising liquid product, near-size catalyst particles, and fine catalyst particles;

30

subjecting, in a secondary filtration stage, the primary filtrate to secondary filtration to separate the near-size catalyst particles and, optionally, some of the fine catalyst particles, from the liquid product, thereby to obtain a secondary filtrate comprising liquid product and, optionally, fine catalyst particles;

allowing a cake of catalyst particles to build up on the filtration medium in the primary filtration stage;

from time to time interrupting the passage of liquid product through the filtering medium in the primary filtration stage; and

- 5 backflushing the filtering medium by passing secondary filtrate, as a flushing liquid, through the filtering medium in a second direction, opposite to the first direction, for at least portions of the periods that the liquid product passage is interrupted, thereby to dislodge the cake from the filtering medium.
- 10 While the process can, at least in principle, have broader application, it is envisaged that the suspension liquid will normally, but thus not necessarily always, be the liquid product.

15 Furthermore, while it is also believed that, in principle, the process can have broader application, it is envisaged that it will have particular application in hydrocarbon synthesis where the gaseous reactants are capable of reacting catalytically in the slurry bed to form liquid hydrocarbon product and, optionally, gaseous hydrocarbon product. In particular, the hydrocarbon synthesis may be Fischer-Tropsch synthesis, with the gaseous reactants

20 being in the form of a synthesis gas stream comprising mainly carbon monoxide and hydrogen, with both liquid and gaseous hydrocarbon products being produced, and with the catalyst particles thus being Fischer-Tropsch catalyst particles.

- 25 The slurry bed will thus be provided in a suitable vessel, eg a column, with unreacted reactants and gaseous product being withdrawn from the vessel above the slurry bed. The vessel will be maintained at normal elevated pressure and temperature conditions associated with Fischer-Tropsch synthesis, eg a predetermined operating pressure in the range 10 to 50 bar,
- 30 and at a predetermined temperature in the range 180°C and 280°C, or even higher for the production of lower boiling point product.

The catalyst particles can, at least in principle, be any desired Fischer-Tropsch catalyst, such as an iron-based catalyst, a cobalt-based catalyst, or

any other Fischer-Tropsch catalyst. Supported catalysts, which are physically stronger than unsupported catalysts, are typically used.

5 The large catalyst particles in the slurry bed thus have particle sizes greater than x microns. The near-size catalyst particles have sizes smaller than x microns, but close to x microns, and are typically not smaller than 1 micron. Thus, the near-size catalyst particles can range in size from 1 micron to about x microns. The fine catalyst particles are significantly smaller than x microns, and are typically smaller than 1 micron. When the catalyst is a cobalt-based
10 catalyst, the catalyst inventory in the slurry bed typically comprises less than 5 volume % particles smaller than $45\mu\text{m}$ and typically less than 1 volume % particles smaller than $22\mu\text{m}$. In a specific application, the slurry bed catalyst inventory may comprise less than 6 volume % particles smaller than $44\mu\text{m}$ and typically less than 3 volume % particles smaller than $22\mu\text{m}$, when the
15 catalyst is a cobalt-based catalyst.

It will be appreciated that there will normally be some overlap between the particle sizes in the various categories. The catalyst particles will normally be more-or-less spherical so that the particle sizes are thus the diameters of the
20 particles.

The catalyst particles may have a desired particle size range, eg no particles greater than 300 microns and less than 5% by mass of the particles being smaller than 22 microns. The catalyst particle size range may be selected,
25 bearing in mind the filtering medium. Conversely, the filtering medium may be selected bearing in mind the catalyst particle size range.

The controlling dimension of the filtering openings is typically 25 microns for an iron-based Fischer-Tropsch catalyst, and typically 10 microns for a cobalt-
30 based Fischer-Tropsch catalyst. Thus, in the case of an iron-based catalyst, catalyst particles larger than 25 microns are filtered out in the primary filtration stage and form the cake on the filtering medium; catalyst particles having sizes in the range 1 micron to 25 microns are then considered near-size catalyst particles; while those smaller than 1 micron are fine catalyst particles.

The near-size catalyst particles, in the case of an Iron-based catalyst, tend to settle slowly and move with the liquid product; these particles are hard and do not fragment readily. The fine catalyst particles are significantly smaller than the controlling dimension; they do not settle and remain with the liquid product.

When using catalyst particles that are physically strong, eg supported cobalt catalyst particles, it is important to ensure that the slurry bed at all times does not contain an appreciable proportion of catalyst particles of a size close to the controlling dimension aperture or opening size of the filtering medium, ie near gap-size particles, since such sized particles can cause permanent blockage of the filtering medium.

Any suitable filtering medium can, at least in principle, be used in the primary filtration stage. Typically, substantially all the filtering openings of the filtering medium will normally be of nominally the same size and have the same geometry. The filtering medium may be part of a filter cartridge or element mounted in the vessel, and may be of a type which is of elongate form, with the filtering medium being of cylindrical form and enclosing a filtrate collecting zone, and with a filtrate outlet for withdrawing filtrate, ie liquid product, being provided at one end thereof. Thus, the filtering medium can be that of a candle filter. While, in principle, the filtering medium can be any desired filtering medium having filtering openings with a controlling dimension of x microns, it is preferably of a type or construction with which permanent clogging or impregnation thereof with the catalyst particles does not readily occur. Thus, the filtering medium can be a mesh, eg a woven mesh; a porous material such as a ceramic material; a perforated sheet; spiral wire wound, eg from wedge wire; or the like.

By 'controlling dimension' in respect of the filtering openings is meant the dimension thereof that determines the maximum catalyst particle size that can pass through the openings. The controlling dimension may, for example, be obtained from the filter manufacturer's specification. Thus, it may be the

upper tolerance level, or it may be the average opening or gap size added to a factor of, eg three times, the gap size standard deviation.

5 The filtering openings may thus be of any desired shape. In one embodiment, the filtering medium openings, when seen in the direction of liquid flow through the openings, may be circular; the controlling dimension of each opening is then its diameter. Instead, in another embodiment, the filtering medium openings, when seen in the direction of liquid flow through the openings, may be more-or-less rectangular so that the width of each opening is shorter than its length; the controlling dimension of each opening is then its width.

10 In one embodiment of the invention, the primary filtration stage may be located externally, ie outside the slurry bed, eg outside the reactor. However, 15 in another embodiment of the invention, the primary filtration stage may be located internally, ie inside the slurry bed.

20 When the primary filtering stage is located internally, a plurality of the filter elements, located at the same or different levels within a filtration zone, may be provided. The filtration zone may be provided anywhere below the upper surface of the slurry bed. The filter elements may be arranged in a plurality of banks, with each filter bank comprising a number of the filter elements.

25 In principle, the elements can be located at any desired inclination; however, they are preferably located vertically with their liquid product or primary filtrate outlets directed downwardly.

30 The passage of the liquid product through the filtering media may be effected by applying a pressure differential across the filtering media and any cake build-up thereon. Preferably this pressure differential may be up to 8 bar, and is typically in the region of between 1 and 4 bar. The pressure differential may be effected by withdrawing the primary filtrate into a primary filtrate collection vessel which is at a lower pressure than the reactor vessel, with the filtrate outlets of the filter elements being connected to the primary filtrate collection

vessel by means of suitable liquid product conduits. The conduits may include a first filtrate conduit leading from the filtrate outlet of each filter element; a second filtrate conduit into which the first conduits of all the filter elements of the particular bank of filter elements tie; and a third filtrate conduit leading to the primary filtrate collection vessel, with the second conduits all tying into the third conduit.

The secondary filtration stage will normally be located outside the reactor. The secondary filtration stage may be provided by any filtration means capable of removing the near-size catalyst particles. Typically, it may be provided by a Schenk or pressure leaf filter.

Suspensions containing fine particulate material that readily blocks the openings in a filter medium can be filtered to lower (impurity/particle concentrations) levels by inclusion of inert, readily filterable granular filter aid materials. Examples of inert filter aid materials are highly porous diatomaceous silica, powdered glass, Fuller's earth etc. The filter aid is pre-coated onto thin leaves or screens that are located either vertically (pressure leaf filters) or horizontally (Schenk filters). The pre-coat is usually achieved by continuously recycling clean filtrate, to which filter aid has been added, until all the filter aid has formed a porous cake on the screen. The cake is permeable to the liquid feed but acts as a depth filter to the fine particulate material, preventing their passage through the filter aid micro-channels and the support screens. Once a predetermined pressure drop over the pre-coat filter is achieved, due to blocking of the micro-channels by the solid impurities, the cake is removed from the screen by means of a mechanical action, eg by rotary, shaking, tapping or hammering action. The 'dirty' filter cake is removed, for example, through a slide valve at the bottom of a conical vessel, for disposal or reclamation.

Any catalyst particles still present in the secondary filtrate are thus fine catalyst particles, and are, as hereinbefore described, typically smaller than 1 micron. Schenk or pressure leaf filters will remove substantially all near-size particles, for both Fe and Co catalysts.

The secondary filtration stage may thus be located downstream of the primary filtrate collection vessel. A secondary filtrate collection vessel may be provided downstream of the secondary filtration stage.

5

The backflushing may be effected for at least portions of the periods that the liquid product passage through the filtering medium of the primary filtering stage is interrupted.

10 The backflushing may, in general, be effected in pulse-like fashion. Thus, the backflushing may comprise an initial pulse of flushing liquid, optimally followed by one or more further pulses of flushing liquid. Each backflushing pulse may comprise initiating backflushing rapidly, ie commencing flow of flushing liquid rapidly; and backflushing the elements rapidly with a volume of the flushing
15 liquid. This volume of flushing liquid may be relatively large, eg approximately equivalent to the internal volume of the filter elements. It can, however, be less than the internal volume of the filter elements, eg less than half their internal volume. When the volume of flushing liquid used during the initial pulse is relatively large, the volume of flushing liquid used during a second
20 pulse may be less than that of the initial pulse, eg less than half the internal volume of the elements. However, when the volume of flushing liquid used during an initial pulse is relatively small as hereinbefore described, then the volume of flushing liquid during a further or second pulse may be similar to that of the initial pulse. The nature of any further pulses, when utilized, and
25 the volume of the flushing liquid used during such pulses, may be similar to those of the second pulse hereinbefore described.

The pressure differential across the filtering media and filter cake during backflushing may be up to 10 bar depending on the degree of clogging or age
30 of the filtering media, and is typically at least 1 bar higher than the filtration pressure differential.

The flushing liquid flow rate may be at least $6000 \ell/h/m^2$ of filtering media. Thus, the flushing liquid flow rate may be between $6000 \ell/h/m^2$ of filtering

media when the pressure differential across the filtering media is about 5 bar, and between about 10000 and 12000 $\ell/h/m^2$ when the pressure differential is about 10 bar.

- 5 The process preferably includes subjecting the filtering elements to a waiting period during which no filtering or backflushing takes place, ie during which there is no liquid flow through the filtering media of the elements, to enhance subsequent filtration. The waiting period may be up to 60 minutes, or even longer, but is typically less than 30 minutes, and can even be less than 1
10 minute.

The backflushing may be effected in a similar manner, and using similar backflushing means, as described in ZA 94/0582 // US 5599849 /
15 US 5844006, which is hence incorporated herein by reference. Thus, backflushing may be effected by propelling or forcing residual liquid product in the conduits back through the filter elements in the second direction, preferably also through a restriction orifice located in the primary conduit of each filter element, by means of pressurized gas. It has been found that
20 cleaning of the filter element surfaces is considerably improved, thus enhancing subsequent filtering performance thereof, when backflushing is effected for at least a sufficiently long period of time to displace substantially all the residual liquid product through the restriction orifices back into the filter elements.

25 The filtrate conduits and the secondary filtrate collection vessel may conveniently form part of the backflushing means, with the secondary filtrate collection vessel also constituting a flushing liquid vessel and some of the filtrate conduits constituting at least some of the flushing liquid conduits. The backflushing means may include at least one quick opening valve or the like,
30 for effecting the backflushing pulses, in one of the flushing conduits; and pressurizing means for pressurizing the flushing liquid vessel. Thus, backflushing may be effected by pressurizing the flushing liquid vessel when the vessel contains secondary filtrate, and then actuating the quick opening valve until the desired volume of flushing liquid gas has passed through the

filter elements of a bank of the filter elements in the second direction. Instead of utilizing a pressurized flushing liquid vessel, a pump can be used for supplying the flushing liquid to the filter elements.

- 5 To inhibit settling of catalyst particles in the slurry bed, the process may include agitating the slurry in the slurry bed. The agitation may include allowing slurry in the slurry bed to pass downwardly from a high level to a lower level, through at least one downcomer. Preferably, the slurry may be allowed to pass downwardly through at least one downcomer located in a first
10 downcomer region of the slurry bed, as well as through at least one further downcomer located in a second downcomer region of the slurry bed, with the second downcomer region being spaced vertically with respect to the first downcomer region, so as to redistribute the catalyst particles within the slurry bed, as taught in ZA 98/5992 // PCT/GB98/02070 which is hence incorporated
15 herein by reference. Thus, the downcomer(s) serve(s) to impart a nett upward liquid velocity to the slurry bed in the regions of the slurry bed outside the downcomers thereby maintaining the catalyst in near uniform suspension.

20 The process may include operating the column such that the slurry bed is in a heterogeneous or churn-turbulent flow regime and comprises a dilute phase consisting of fast-rising large bubbles of gaseous reactants, and possibly gaseous products which traverse the reaction zone or slurry bed virtually in a plug flow manner and a dense phase comprising liquid phase, ie liquid product, solid catalyst particles and entrained smaller bubbles of gaseous
25 reactants and gaseous product.

By passing or recirculating some of the slurry through the downcomers, more uniform redistribution of the catalyst in the slurry bed is achieved, than is the case without such downcomers. The catalyst particles in the slurry bed are
30 thus maintained in suspension by the turbulence created by the synthesis gas stream passing through the slurry bed combined with an upward liquid velocity induced by the presence of the downcomers. It was found that the use of downcomers to keep the catalyst particles in uniform suspension, avoids the

problem of catalyst settling when selecting the optimum catalyst particle size distribution.

5 The invention will now be described by way of example with reference to the accompanying drawings.

In the drawings,

10 FIGURE 1 shows a simplified flow diagram of a process according to the invention for producing liquid and gaseous products from gaseous reactants;

FIGURE 2 shows an enlarged side view of one of the filter elements shown in Figure 1;

FIGURE 3 shows, in part, an enlarged sectional view through III-III in Figure 2; and

15 FIGURE 4 shows, in part, a sectional view through IV-IV in Figure 2.

In the drawings, reference numeral 10 generally indicates a process according to the invention for producing liquid and gaseous products from gaseous reactants.

20

The process 10 includes an upright cylindrical Fischer-Tropsch synthesis slurry phase reactor vessel 12.

25 The vessel 12 provides a slurry bed zone normally containing a slurry bed 14 of catalyst particles suspended in liquid product and through which gas is passing, as described in more detail hereunder. The slurry bed 14 has an upper surface 16. The expanded height of the slurry bed 14, while gas passes through it, is typically between 14 and 18m when the total reactor length is about 24m.

30

A synthesis gas flow line or conduit 18 is connected to a gas distributor 20 provided at the bottom of the vessel 12, while a gas withdrawal flow line or conduit 22 leads from the top of the vessel 12.

The process 10 also includes a plurality of candle filter elements 30 (only some of which are shown) located in a filtration zone 22 within the slurry bed 14, arranged in a plurality of banks. Each filter element 30 is of elongate cylindrical form, and comprises a cylindrical filtering medium 32 enclosing a filtrate or liquid collecting zone 33. The medium 32 is located between an end plate 34 and a support ring 36. A mounting rod 38 protrudes from the end plate 34, while a flanged liquid outlet 40 is provided on the support ring 36. Thus, by means of the outlet 40, primary filtrate or liquid product can be withdrawn from the collecting zone of the element or cartridge 30. The elements 30 are mounted in position in the vessel 12 by means of the rod 38 and flanged outlets 40. This mounting is not shown in detail in the drawings, but is typically effected by connecting the rod 38 to a lattice or grid spanning the vessel 12, while the outlet is connected to a conduit as hereinafter described.

The filtering medium 32 comprises a spiral wound wire 42 embedded in, or attached to, circumferentially spaced elongate supports 44 extending between the end plates 34, 36. Filtration openings or slots 46 are thus provided between adjacent loops of the wire 42. The wire 42 has, adjacent the openings or slots 46, surfaces 47 which taper away from each other, in the direction of the collecting zone. The wire 42 thus also has surfaces 48 against which a cake of catalyst particles (not shown) will form, as described in more detail hereunder, when liquid product is filtered by the elements 30 as it passes through the slots 46 in the direction of arrow 49. As a result of the tapering surfaces 47, solid catalyst particles will not readily permanently clog or impregnate the openings or slots 46 when filtered product passes through in the direction of arrow 49.

Typically, the filter elements 30 have an external diameter of 2 to 12cm, with the wire 42 being of stainless steel. The width of the wire 42 at its base is typically about 1,2mm, but preferably is 0,8mm or 0,5mm. This ensures a lower variation in the width of the slots and reduces the number of openings in excess of the average slot width. The average widths of the slots or openings 46 are typically from 10 to 25 microns, but preferably are not greater than 20

microns. This reduces the possibility of the controlling dimension of a filter being greater than desired. A catalyst content of 10ppm or less in the filtered wax can thereby be achieved. The greater the variation in the gap size and the greater the maximum opening of any filter gap, the greater the possibility of particles larger than the average gap size passing through the filter media. Those versed in the art of filtration know that this will reduce the separation efficiency of the filtration system. It was found that this variation also increased the potential for blinding of the filters during backflushing due to the particularly hard nature of the proprietary cobalt Fischer-Tropsch catalyst. The near gap size hard catalyst particles can become irreversibly lodged in the backflush side of the filter media.

Instead of the filter elements 30, any other suitable elongate filter elements or cartridges, such as ceramic or sintered metal filter elements, can be used.

The filtration zone 22 is preferably located at a high enough level within the slurry bed, so that the filter elements 30 are located outside the zone of settled catalyst if the gas supply 18 is interrupted. As a result, they will not be embedded in settled solids or catalyst on slumping of the bed 14. However, it has been found that the filtration zone 22 need not necessarily be located near the top of the slurry bed 14 but can instead be located lower down since, should such bed slump occur, it has been found permanent clogging of the filter elements 30 will still not readily occur even if the elements are completely surrounded by settled solids or catalyst. The filter elements 30 are preferably located at a low enough elevation so that they remain submerged in liquid and are not exposed to gas if the gas supply is interrupted, but filter exposure is acceptable if the filter surface is shaped so as to avoid catalyst laydown.

The elements 30 are preferably located with their outlets 40 directed downwardly so that any solid or catalyst fines which pass through the slots 46 with the filtrate (liquid product) will tend to collect in the bottom of the collection zones of the filter elements 30 from where they will be washed out with the liquid product.

To the outlet 40 of each of the filter elements 30 is connected a primary conduit 51, fitted with a restriction orifice 50. The conduits 51 of all the filter elements 30 making up a bank of the elements tie into a common secondary conduit 53 fitted with a shut-off valve 52. All the conduits 53 tie into a
5 common tertiary conduit 54, fitted with a quick opening valve 56.

The conduit 54 leads into a primary filtrate blowdown vessel or drum 58 and is provided with a shut-off valve 60. A conduit 62 leads from the drum 58 to a secondary filtration stage 64 comprising Schenk filters. A residue withdrawal
10 line 66 leads from the stage 64 as does a secondary filtrate withdrawal line 68. The line 68 is fitted with a shut-off valve 70.

The conduit 68 leads into the top of a secondary filtrate blowdown vessel 72. A liquid rundown conduit 74, fitted with a shut-off valve 76, leads from the
15 bottom of the vessel 72. A liquid backflush conduit 78, fitted with a shut-off valve 80, leads from the conduit 74, upstream of the valve 76, back to the conduit 60, between the valves 56, 60.

A pressurizing gas conduit or line 82, fitted with a control valve 84, leads into
20 the top of the vessel 72, while a vent conduit or line 86, fitted with a control valve 88, leads from the top of the vessel 72.

Instead of the pressurizing conduit 82 being provided, a pump (not shown) may be provided in the conduit 78.
25

The column 12 includes at least one downcomer 82. A cooling coil 84 is also provided below the downcomer 82.

If desired, the downcomer 82 may be provided in a first downcomer region,
30 with the column 12 also including a second downcomer region (not shown), spaced with vertical clearance from the first downcomer region. At least one downcomer (not shown) will then be provided in the second downcomer region, with this downcomer not being aligned axially with the downcomer 82.

In use, synthesis gas, comprising mainly carbon monoxide and hydrogen, enters the reactor vessel 12 along the flow line 18. The gas flow rate to the vessel 12 is such as to give a superficial gas velocity in the filtration zone 22, based on the open cross-sectional area of the filtration zone, of between 5 and 70cm/s, typically about 30 to 40cm/s.

The slurry bed 14 is maintained in the reactor vessel 12. The slurry bed 14 comprises catalyst particles suspended in liquid product, ie liquid wax produced in the vessel 12 on reaction of the gaseous reactants. The catalyst particles are maintained in suspended state in the slurry bed 14, and in particular in the filtration zone 22, by means of the turbulence created therein by the gas passing upwardly therethrough. It is believed that this turbulence also inhibits excessive cake build-up on the filtering media, and thus enhances filtration through the media.

The vessel 12 is typically maintained at an operating pressure of between 20 bar and 30 bar, typically about 25 bar, and at an operating temperature between 180°C and 260°C, typically between about 220°C and about 240°C. However, the operating pressure can be in excess of 25 bar, and the operating temperature higher than 240°C or lower than 220°C, as hereinbefore described, depending on the nature and spread of gaseous and liquid products required and the type of catalyst used. Naturally, the vessel 12 will be provided with suitable temperature control means, such as the cooling coil 84 for controlling the reaction temperatures, as well as suitable pressure control means such as a pressure control valve.

In the vessel 12, as the synthesis gas passes through the slurry bed 14, the carbon monoxide and hydrogen react to form a range of products in accordance with known Fischer-Tropsch reactions. Some of these products are in gaseous form at the operating conditions of the vessel 12 and are withdrawn, together with unreacted synthesis gas, along the flow line 20. Some of the products produced, such as the waxes already mentioned, are in liquid form at the operating conditions of the vessel 12, and act as the suspension medium for the catalyst particles. As liquid product is formed, the

level 16 of the slurry bed naturally rises, and the liquid product is thus withdrawn in the filtration zone by means of the filter elements 30 and rundown vessel 58 to maintain the slurry bed level. This internal filtration constitutes a first stage of the operating cycle of the filter elements 30.

The catalyst used is typically an iron- or cobalt-based catalyst, and a product mixture comprising liquid product and iron catalyst particles having a range of sizes is formed in the slurry bed. For an iron-based catalyst, the controlling dimension of the filtering medium of the filter elements 30 is typically 25 microns. The product mixture will then contain large catalyst particles having a dimension, eg diameter, greater than x microns, near-size catalyst particles being from 1 to 25 microns in size, and fine catalyst particles smaller than 1 micron. The large catalyst particles will thus not pass through the filtering openings 16 of the filter elements and will build up as a cake on the outside of the filter elements. Primary filtrate comprising liquid product, near-size catalyst particles and fine particles, will pass through the filtering openings and, by means of the conduits 53 and 54, into the vessel 58. From there it passes through the secondary filtration stage 64 where the near-size particles are removed from the liquid product. Secondary filtrate comprising liquid product and fine catalyst particles passes from the secondary filtration stage 64, by means of the line 68, into the vessel of drum 72.

The vessel 72 is maintained, by means of pressurizing gas introduced along the line 82, at elevated pressure, which is, however, lower than that in the vessel 12. Typically the pressure in the vessel 72 is set such that the pressure differential across the filtering media of the filtering elements 30 and any filter cake build up thereon, is about 2 to 4 bar.

In this fashion, a relatively constant slurry bed level in the reactor is maintained. However, when the filter cake has built up to some thickness, it must then be backflushed from the filtering media, in a second stage of the operating cycle of the filter elements 30. The backflushing is effected by shutting the quick opening valve 56 and valve 60, and withdrawing at least some of the liquid product in the rundown vessel 72, through the flow line 74,

In order to remove any solids which have settled out in the bottom of the vessel 72. The pressure in the vessel 72 is then increased, by means of the gas pressurizing line 82, to a pressure greater than the operating pressure in the vessel 12. As a result of the static head of liquid (wax) in the rundown
5 conduits, the liquid pressure at the quick opening valve 56 is typically slightly lower than the pressure in the vessel 72, but still sufficient for backflushing. The vessel 72 will thus contain secondary filtrate.

Backflushing is effected in pulse-like fashion on one bank of filter elements 30
10 at a time, using secondary filtrate from the vessel 72. Thus, during backflushing, one of the valves 52 will be open, with the remaining valves 52 closed. The valve 80 will be open. In a first backflushing step, the quick opening valve 56 is opened rapidly in less than 0,8 seconds, and a volume of secondary filtrate, typically approximately equivalent to the internal volume of
15 the filter elements 30 making up the bank of elements being flushed, is allowed to pass from the vessel 72, to produce a flow through the backflushing conduit 78, and the conduits 54, 53 and 51, thereby to provide flushing liquid through the bank of elements 30, in a second direction opposite to the direction in which the product flows during filtering. This typically takes
20 up to 30 seconds. Thereafter, the quick opening valve 56 is again shut.

If a second backflushing step is desired, the vessel 72 is then again repressurized. In a second pulse-like backflushing step, the quick opening valve 56 is again opened rapidly for a second time. This time a flushing liquid
25 volume equivalent to about one-third of the volume in the first backflushing operation, is typically allowed to pass from the vessel 74 to the filter elements 30. The valve 56 is thereafter again closed. If desired, at least one further similar backflushing step can be effected on that particular bank of filter elements.

30 The remaining banks of elements can then similarly be backflushed, by opening and closing the appropriate valves 52.

Thereafter, in a third stage of the operating cycle of each bank of filter elements 30, they are subjected to a waiting period in which no liquid passes through them. The Applicant has found that the filtration rate, when the filter elements 30 are then thereafter again subjected to filtration as hereinbefore described, increases with an increase in the duration of the waiting or non-active period. However, this must be balanced against the disadvantage that the filter elements are out of service during these waiting times. It has been found that a waiting period of between 10 and 30 minutes gives good results. However, the waiting period can also be shorter than 10 minutes. It is believed that, during this waiting period, catalyst cake which has been loosened from the filter media of the elements 30 and partially broken up during the backflushing stage, is effectively broken up further, removed from the filter media surfaces and re-mixed remotely from the filters 30, by means of the turbulence within the slurry bed 14. It is believed further that the gas superficial velocity through the filtration zone 22 may influence the optimum duration of the waiting period.

Some slurry continuously passes downwardly through the downcomer 82, thereby to achieve uniform redistribution of catalyst particles within the slurry bed 14, and also to ensure uniform heat distribution throughout the slurry bed, as also described in more detail hereunder.

The vessel or column 12 is operated so that the slurry bed 14 thereof is in a heterogeneous or churn-turbulent flow regime and comprises a dilute phase consisting of fast-rising larger bubbles of gaseous reactants and gaseous product which traverse the slurry bed virtually in plug flow fashion, and a dense phase which comprises liquid product, solid catalyst particles and entrained smaller bubbles of gaseous reactants and gaseous product.


The Applicant has found that when the filter elements of a primary filtration stage are backflushed with primary filtrate, ie primary filtered wax, to remove cake formation thereon, blockage of the filters from the inside can result. This is as a result of the presence of near-size catalyst particles and fine catalyst particles in the primary filtrate. This type of blockage is irreversible and is

caused by the presence of the near-size catalyst particles in the primary filtrate or even by the fine catalyst particles, if present in the primary filtrate in large quantities.

- 5 The present invention thus provides a means for overcoming this problem, since the near-size catalyst particles are removed from the primary filtrate in the secondary filtration stage 64.

DATED THIS 15TH DAY OF JULY 2003.

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ADAMS & ADAMS
APPLICANTS PATENT ATTORNEYS

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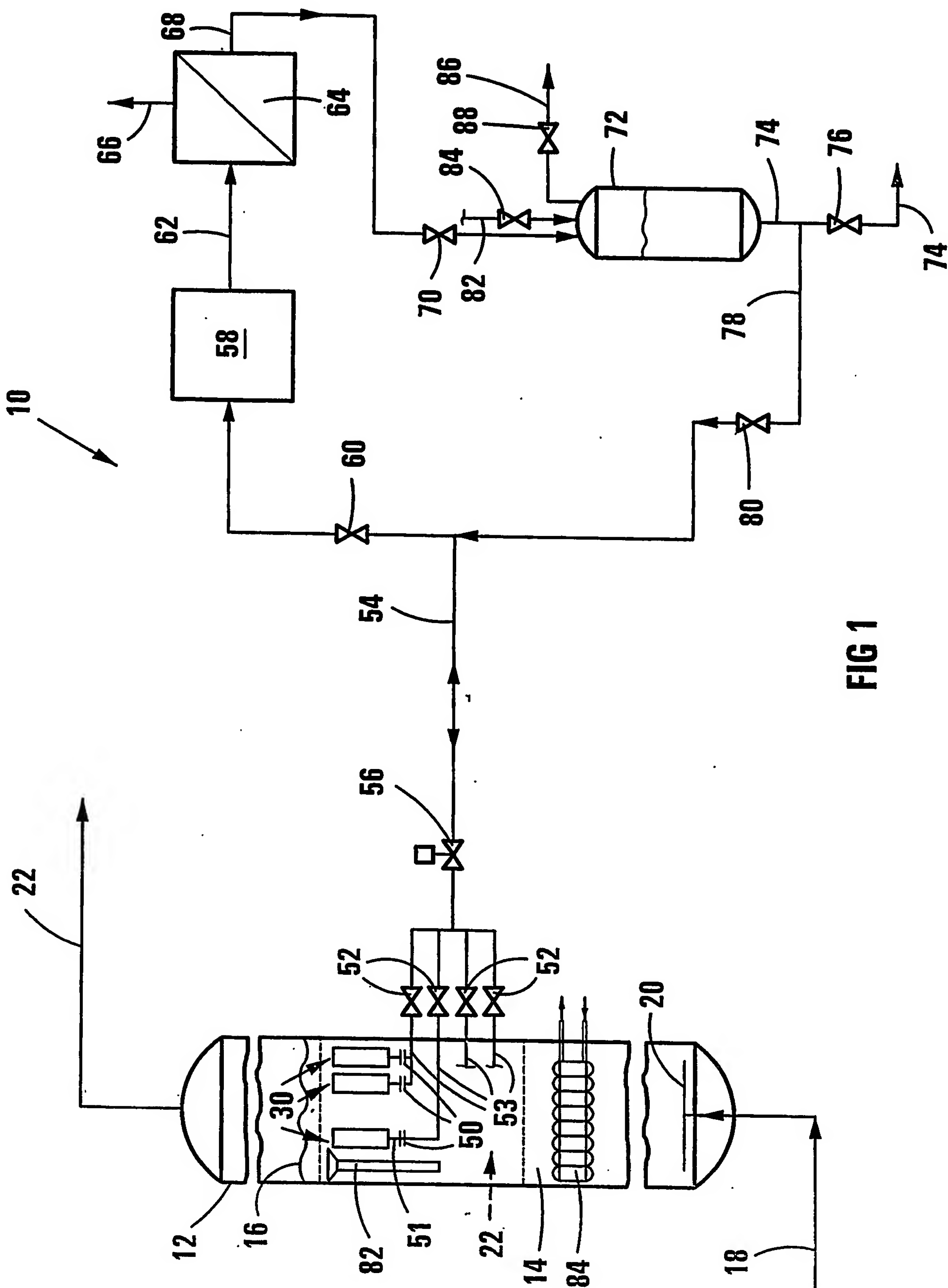


FIG 1

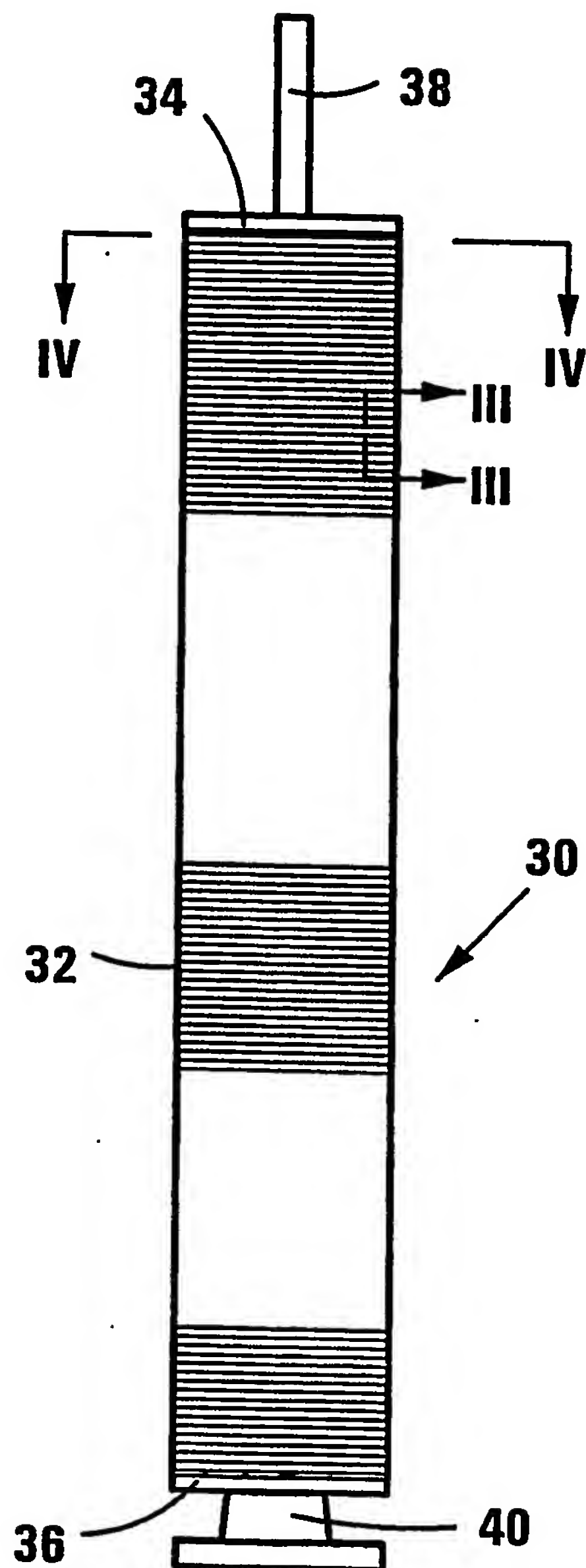


FIG 2

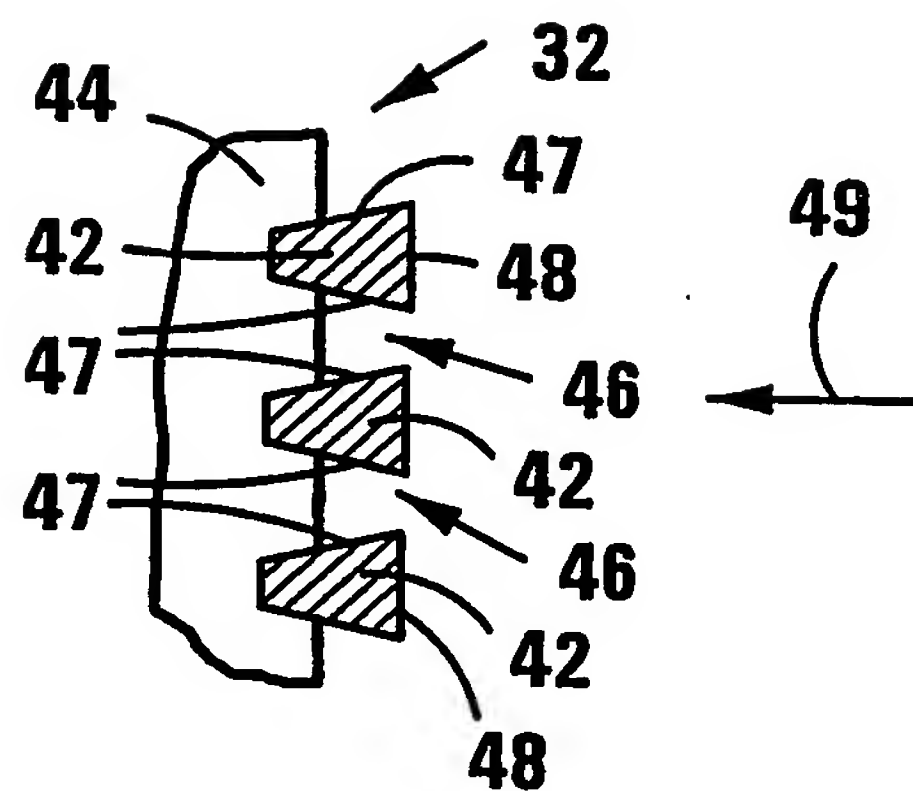


FIG 3

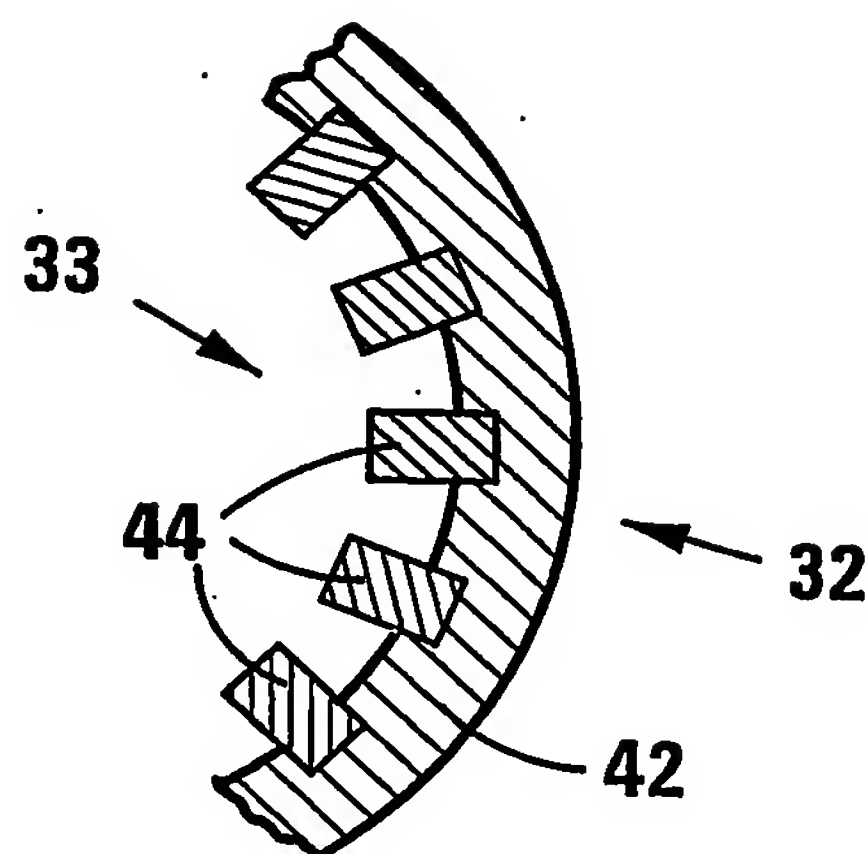


FIG 4

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